SF

CHM 1025
FIRST PROBLEM SET

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MATH REVIEW

1. Perform the indicated algebra: (For help see the appendices in your text.)

   a. $a^m \times a^n =$ b. $a^{(m+3)} \div a^{(2m+2)} =$ c. $a^0 =$ d. $a^{-2} =$

   e. Since $a^{1/4} = \sqrt[4]{a}$, what does $a^{1/n} = ?$

QUESTIONS ON SIGNIFICANT FIGURES

(Complete handout on Measurements & Sig Figs before doing problems below)

2. How many significant figures are in each of the following?

   a. 9 baseballs b. 90 baseballs c. 9,000,000 baseballs
   d. 3 dozen ostrich eggs e. 0.1 cm f. 100.10 cm
   g. 1.01 in. h. 0.005 g i. 0.00500 g

3. Rewrite the values in problem 1 e-i in suitable scientific notation.

4. Do the indicated arithmetic paying strict attention to significant figures and units.

   a. 0.034 cm + 0.0340 cm b. 0.034 cm × 0.0340 cm c. 0.034 cm - 0.0340 cm
   d. 0.034 cm ÷ 0.034 cm e. 0.034 cm-0.0034 cm

5. Perform the following calculations and report the answer to the proper number of significant figures (without the aid of a calculator):

   a. 9.75 in + 0.326 in b. 1.025 sec - 0.09 sec c. $(1.61 \times 10^{15}\ A) + (1.61 \times 10^{16}\ A)$
   d. $(5.6 \times 10^{-2}\ m)^2$ e. $\sqrt[3]{4 \times 10^5\ g \times 3 \times 10^{-3}\ g}$

6. Perform the following SI conversions making proper use of unit conversion analysis:

   a. 971 mg = kg b. 82 s = ms c. $12.3\ cm^2 = mm^2$
   d. $0.213\ L = cm^3$ e. $6.50\ m^{-1} = cm^{-1}$ f. 7.61 kg/L = mg/mL

7. You are given 1000 equal sized gem stones with a total mass of exactly 3 g. These gems are valued at $1000 per oz. (Note: 1.000 oz = 28.35 g) Answer the following using unit - factor analysis.

   a. How much money are you out if you lose 50 stones?

   b. If you now receive an additional handful of these gems, how would you determine the value of this handful by weighing? Tell exactly how you would go about it.

   c. Could you determine the value of this handful by a counting procedure? What assumption would the counting procedure depend upon?

8. A circular cheese pizza with a 10" diameter sells for $5.00. The same pizza with a 14" diameter sells for $10.00. Which is the better buy? (Remember: area of a circle = πr^2)

9. Medium thin-rind grapefruit (diam. = 2.0") sell for 10¢ each. Large thin-rind grapefruit (diam. = 3.0") sell for 20¢ each. Consider the fruit to be spherical. Which is the better buy? (Remember: volume of a sphere = $4/3\pi r^3$)

QUESTIONS ON MATTER and ENERGY

10. What are the general properties of metals and where are they found in the periodic table?

11. What are the general properties of nonmetals and where are they found in the periodic table?

12. Characterize each of the following as a physical or chemical process:
    a. copper wire produced from a bar of copper
    b. the attraction of an iron nail by a magnet
    c. dissolving sugar in water
    d. evaporation of water from a lake
    e. combustion of coal
    f. burning of magnesium ribbon in a military flare
    g. heating the filament of an incandescent lamp to provide light
    h. crystallization of sodium carbonate from water
    i. dissolving an Alka-Seltzer in water
    j. silver tarnishing in air

13. Consider both of the following descriptions. For each list the extrinsic properties stated and the intrinsic chemical and physical properties.
    a. Sucrose is a colorless solid that chars or blackens upon being heated or may even ignite and burn with a yellow flame. Its density is 1.6 g/mL. Usually it is in the form of small crystals (table sugar), although it can be in the form of a powder.

    b. Sodium metal can be prepared by electrolysis of molten sodium chloride. Solid sodium is soft and easily cut, silver-white in color and is a good conductor of electricity. The liquid boils at 883°C and the vapor is violet-colored. Sodium metal tarnishes rapidly in air and burns on heating in air or in an atmosphere of bromine vapor.

14. Convert each of the following temperatures to the scale indicated:

a. 6.7 °C to °F	b. -18 °F to °C	c. 355 °C to K
d. 150 K to °C	e. 120 °F to K	f. 200 K to °F

15. Suppose I define a new temperature scale (Hokie, °H) where the freezing point of H_2O is -40°H and the boiling point of H_2O is 320°H.

    To what temperature in °C does 100°H correspond? From a significant figure standpoint, which scale the °H or the °C more precisely defines the temperature? Why?

16. Classify the following processes as endothermic or exothermic:
    a. melting of ice b. evaporation of alcohol c. combustion of methane
    d. frying an egg e. carbohydrates metabolized by the body

17. When washing soda (Na_2CO_3) is stirred into H_2O initially at 25°C the temperature of the resulting solution is greater than 25°C. Is the dissolution process exothermic or endothermic? Explain.

18. When Chilean saltpeter (KNO_3) is stirred into H_2O initially at 25°C the temperature of the resulting solution is less than 25°C. Is the dissolution process exothermic or endothermic? Explain.

QUESTIONS ON DENSITY

19. A cube with edge = 1.00" of an unknown pure substance has a mass of 10.0 oz. What is the density of this substance in g/mL? In kg/L? (Remember: 1 mL = 1 cc exactly and 1.00 oz = 28.35 g)

20. Osmium is the densest element known. What is the density of osmium if 2.72 g of osmium has a volume of 0.121 mL?

21. What is the mass of each of the following?
    a. 6.00 cm^3 of mercury; density = 13.5939 g/cm^3
    b. 4.00 cm^3 of solid sodium; density = 0.97 g/cm^3
    c. 125 mL of gaseous chlorine; density = 3.16 g/L

22. What is the volume of each of the following?
    a. 25 g of iodine; density = 4.93 g/mL
    b. 3.28 g of gaseous hydrogen; density = 0.089 g/L
    c. 11.3 g of graphite; density = 2.25 g/cm^3

23. Determine the density of a block of metal weighing 20.12 g which when immersed in water contained in a graduated cylinder causes the water level to rise from 15.5 mL to 21.5 mL.

24. A graduated cylinder has a mass of 57.832 g. An organic liquid, toluene, with a density of 0.866 g/cm^3 is added until the combined mass reads 87.127 g. What is the volume of the liquid in the graduated cylinder?

25. Consider that in the lab experiment for the density determination of an unknown liquid, a drop was lost in transferring the liquid from the buret to the flask for weighing. How would this experimental error affect the result? (I.e., would the experimentally determined density be greater, lesser, or the same as the true density?) Explain.

QUESTIONS ON FUNDAMENTAL LAWS OF CHEMISTRY

26. If 16.0 g of oxygen react completely with 2.0 g of hydrogen to produce water, what mass of water is produced? What natural law are you using to determine the mass of the water?

    If 4.0 g of oxygen are reacted with 2.0 g of hydrogen to produce water and leftover hydrogen, what mass of hydrogen is leftover? What is the mass of water produced? On what natural laws are your responses based?

27. Consider these hypothetical examples of the work of John Dalton on the mythical elements Gazook (G) and Mudd (M) under differing experimental conditions:

    a. 1.00 g G + 3.00 g M $\longrightarrow$ 4.00 g of a new pure stuff, Compound I

    b. 1.00 g G + 6.00 g M $\longrightarrow$ 7.00 g of another pure stuff, Compound II

    c. 1.00 g G + 9.00 g M $\longrightarrow$ 10.00 g of yet another pure stuff, Compound III

    i) What natural law can be used to derive simplest formulas for the products from these data?

    ii) Now, for a, b, and c respectively, what are the SIMPLEST formulas for the products that are consistent with the data?

    iii) If GM_2 is an acceptable formula for compound I, write simplest formulas for the other products?

    iv) If G_2M_5 is an acceptable formula for compound I, write simplest formulas for the other products?

    v) If GM is an acceptable formula for compound II, write simplest formulas for the other products?

QUESTIONS ON FUNDAMENTAL SUBATOMIC PARTICLE

(Read handout on Subatomic Particles before doing problems below)

28. J. J. Thomson showed that cathode ray tubes could be constructed using many different metals as the cathodic electrode material. How do the results of the Thomson experiments support the theory that cathode rays (or electrons as they are known today) are fundamental particles of all matter?

    What did his experiments show about canal rays?

29. The charge/mass (e/m) ratio for an electron is -1.76×10^8 C/g and this ratio for a proton is $+9.58 \times 10^4$ C/g. Use these data to show why chemists may consider an electron to be essentially massless. (Hint. Calculate the ratio of the mass of an electron to the mass of a hydrogen atom.)

30. A student repeats Millikan's oil drop experiment in order to determine the charge on the electron. The results were:

Droplet	Calculated charge
A	-9.6132×10^{-19} C
B	-14.4198×10^{-19} C
C	-4.8066×10^{-19} C
D	-19.2264×10^{-19} C

    a. From these four pieces of data, what is the **LARGEST** acceptable value for the charge on the electron? Explain.

    b. Reconsider the data. Could the value of -2.4033×10^{-19} C also be an acceptable value? Explain.

31. It is now known that static electric charges are caused by the transfer of electrons.

    a. How many excess electrons are present on an object with a charge of -5.5×10^{-15} C?

    b. How many electrons are deficient from an object with a net charge of $+6.4 \times 10^{-12}$ C?

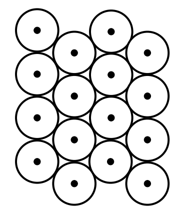
32. What is the net charge, in coulombs, associated with 1.00×10^{12}:

    a. hydrogen atoms ($^{1}_{1}H$)? b. fluoride ions (F^{-})? c. $^{22}_{10}Ne^{+2}$ ions?

33. Why could neutrons not be isolated and detected by the same methods that had been used to characterize electrons and protons?

34. Why is it important to use a very thin foil for the Rutherford experiment?

Packing of Atoms in gold foil



35. Consider that the gold foil used in the Rutherford experiment was 4×10^{-4} cm thick. If Au has an atomic radius of 1.4 Å, on the average through how many Au atoms did each alpha particle (α) pass? (Refer to diagram at right.)

    This question is for your information only!

36. Calculate the density of matter in a proton using Rutherford's estimate of the diameter of a proton of 1.5×10^{-13} cm. The mass of a free proton is about 1.67×10^{-24} g. Assume the nucleus is a sphere ($V = 4/3\pi r^3$). Compare this density with the density of osmium metal (the densest element) which is 22 g/cm^3). Comment about the amount of "empty space" in an atom.

37. Complete the following table:

Elemental Symbol	Number of Protons	Number of Neutrons	Number of Electrons	Charge on Species	Name
$^{190}_{78}Pt$					
$^{41}_{20}Ca^{+2}$					
$^{223}_{87}Fr$					
$^{139}_{53}I^{-1}$					
$^{3}_{2}He$					
		7	6		Carbon Thirteen
	14	15		0	
		18	18	-2	
	26	30	23		
		118	76	+3	

38. Although the symbol ${}^{35}_{17}Cl$ may be preferred to the simpler ${}^{35}Cl$, can you explain why the two actually convey the same information? Do the symbols ${}^{35}_{17}Cl$ and ${}_{17}Cl$ have the same meaning?

39. Are the two atoms described by ${}^{60}X$ and ${}^{60}Y$ atoms of the same element?

40. The mass numbers of the isotopes of hydrogen, called protium, deuterium, and tritium, are 1, 2, and 3, respectively. What are the basic differences in these types of hydrogen atoms?

41. Explain why ${}^{18}O$ and ${}^{16}O$ have essentially identical chemical properties.

42. The mass of a ${}^{12}_{6}C$ atom is taken to be exactly 12 amu. Are there likely to be any other nuclides with an exact integral (whole number) mass, expressed in amu? Explain.

43. Determine the average atomic mass of the following elements given the natural isotopic distributions and absolute isotopic masses:

    a. Potassium, only two natural isotopes: ${}^{39}K$; 38.9637 amu, 93.12% and ${}^{41}K$; 40.974 amu, 6.880%

    b. Neon, three natural isotopes:
    ${}^{20}Ne$, 19.99244 amu, 90.92% ; ${}^{21}Ne$, 20.99395 amu, 0.2570% and ${}^{22}Ne$, 21.99138 amu, 8.820%

    c. Do any potassium or neon atoms exist with your calculated masses?

44. The element silver consists in nature of two isotopes, ${}^{107}Ag$, with isotopic mass of 106.905 amu, and ${}^{109}Ag$, with isotopic mass of 108.905 amu. The accepted atomic mass of Ag is 107.870 amu. From this calculate the relative amounts of ${}^{107}Ag$ and ${}^{109}Ag$ in nature.

QUESTIONS ON BONDING, IONS AND MOLECULES
(Read handout on Simple Nomenclature before doing problems below)

45. What is the difference between an atom and a molecule?

46. What is the difference between an atom, a simple cation, and a simple anion?

47. What is the difference between a molecule and a polyatomic ion?

48. What is the difference between a covalent bond and an ionic bond?

49. Which of the following bonds are likely to be ionic and which covalent?

    a) Na to Cl bond   b) C to H bond   c) B to Cl bond   d) O to Fe bond

50. Correct the following mis-statements.

    a) The formula for carbon dioxide is CO2.   b) Mg^{+2} is an anion.

    c) The molecule of H_2O contains one atom of hydrogen and two atoms of oxygen.

    d) The molecules of sodium chloride (table salt) have the formula of NaCl.

    e) NH_3 (ammonia) is a polyatomic ion.

QUESTIONS ON MOLES, FORMULAS AND PERCENT COMPOSITION

51. Determine the molar mass in grams (the mass of one mole) for each of the following species.
    a. Fe b. N_2O_4 c. $(NH_4)_3AsO_4$ d. CO_3^{-2}

52. Calculate the formula mass (the mass of one formula unit) in amu and in grams for those materials in question 51. (1 amu = 1.66054×10^{-24} g) Make sure that you know the difference between questions 51 and 52!

53. Carry out each of the conversions indicated via the unit - factor analysis approach.
    a. 37.5 g H_2O to moles H_2O
    b. 3.25×10^{-2} moles F^{-1} to g F^{-1}
    c. 4.2 g I_2 to molecules I_2
    d. 39.6 g $(NH_4)_2SO_4$ to formula units $(NH_4)_2SO_4$
    e. 6.26×10^{-3} moles Mg^{+2} to ions of Mg^{+2}
    f. 4.5×10^{25} molecules S_8 to moles S_8
    g. 4.5×10^{25} molecules $C_6H_{12}O_6$ to grams $C_6H_{12}O_6$
    h. 0.25 moles $CaCl_2$ to number of formula units $CaCl_2$

54. Calculate the percentage by mass composition of each element in each of the following compounds to 4 significant figures.
    a. $K_2Cr_2O_7$ b. $C_{12}H_{22}O_{11}$

55. a. Calculate the mass percent of water in $ZnSO_4 \bullet 7H_2O$
    b. Calculate the mass of nitrogen in 30.0 g of the amino acid, glycine, $NH_2CH_2CO_2H$

56. a. A compound composed of xenon and fluorine, was found to be 63.3% Xe and 36.7% F by mass. Calculate the empirical formula.
    b. A new organic compound gave the following elemental analysis:
    60.59% C and 7.12% H. Further analysis revealed oxygen to be the only other element present. Compute the empirical formula for this compound.
    c. Titanium forms two compounds with oxygen. Given the elemental analysis for each compound, calculate the empirical formulas.
    Cpd. I: 59.9% Ti, 40.1% 0 Cpd. II: 66.6% Ti, 33.4% 0

57. Given the following empirical formulas and molecular masses, calculate the molecular formulas:
    a) CH_2, ~70 amu b) CH_2O, ~90 amu c) $AlCl_3$, ~267 amu

58. Determine the empirical formula, molecular formula, and correct molecular mass for each compound:
    a. C, 85.69%; H, 14.31% ; MM ≈ 56 amu (± 2% error)
    b. C, 38.7%; H, 9.7%; O, 51.6% ; MM ≈ 60 amu ± 3 amu
    c. C, 59.0%; H, 7.1%; O, 26.2% ; N, 7.7%; MM ≈ 182 amu ± 4 amu
    d. C, 49.5%; H, 5.15%; N, 28.9% ; O, 16.5%; MM ≈ 195 amu ± 2 amu
    e. C, 1.640 g; H, 0.1032 g; ;N, 0.4780 g; O, 1.365 g ; MM ≈ 420 ± 20 amu

Periodic Table of the Elements

IA																	VIIIA
1 **H** 1.0079	IIA											IIIA	IVA	VA	VIA	VIIA	2 **He** 4.002602
3 **Li** 6.941	4 **Be** 9.012182											5 **B** 10.81	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.998403	10 **Ne** 20.180
11 **Na** 22.9897693	12 **Mg** 24.305	IIIB	IVB	VB	VIB	VIIB		VIIIB		IB	IIB	13 **Al** 26.981539	14 **Si** 28.0855	15 **P** 30.973762	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.08	21 **Sc** 44.95591	22 **Ti** 47.867	23 **V** 50.9415	24 **Cr** 51.996	25 **Mn** 54.93804	26 **Fe** 55.845	27 **Co** 58.93320	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.92160	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.90585	40 **Zr** 91.224	41 **Nb** 92.90638	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.90550	46 **Pd** 106.42	47 **Ag** 107.8682	48 **Cd** 112.41	49 **In** 114.818	50 **Sn** 118.71	51 **Sb** 121.760	52 **Te** 127.60	53 **I** 126.90447	54 **Xe** 131.29
55 **Cs** 132.905452	56 **Ba** 137.33	57 **La*** 138.9055	72 **Hf** 178.49	73 **Ta** 180.94788	74 **W** 183.84	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.217	78 **Pt** 195.08	79 **Au** 196.966567	80 **Hg** 200.59	81 **Tl** 204.3833	82 **Pb** 207.2	83 **Bi** 208.98040	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac**† (227)	104 **Rf** (265)	105 **Db** (268)	106 **Sg** (272)	107 **Bh** (273)	108 **Hs** (276)	109 **Mt** (279)	110 **Ds** (281)	111 **Rg** (273)	112 **Cn** (285)	113 (287)	114 (289)	115 (291)	116 (292)		118 (294)

*	58 **Ce** 140.116	59 **Pr** 140.90765	60 **Nd** 144.242	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.964	64 **Gd** 157.25	65 **Tb** 158.92535	66 **Dy** 162.500	67 **Ho** 164.93032	68 **Er** 167.259	69 **Tm** 168.93421	70 **Yb** 173.05	71 **Lu** 174.9668
†	90 **Th** 232.03806	91 **Pa** 231.03588	92 **U** 238.02891	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (261	103 **Lr** (264

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